PRELIMINARY NOTE ON THE METEORITES IN THE BLOEMFONTEIN MUSEUM.

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(With Plates V., VI., VII., and Text Figures.)

The Bloemfontein Museum contains three meteoric specimens, and as they have not been previously studied, it seemed worth while to undertake an examination of them.

Two of them are fragments of the same fall, and the other one is of quite a different character.

The first two are portions of a fall which occurred at Kroonstadt in the Orange River Colony in 1877 (November 11th), whilst the other fell at Zeekoegat Farm, Winburg, in 1881, but the precise date cannot be ascertained, and in the following account they will be referred to as the Kroonstadt and Winburg specimens respectively.

Kroonstadt Meteorite.

This consists of two fragments, weighing respectively 1,382 grammes and 663 grammes, the external appearance of which is well shown by Figs. 1 and 2 for the larger, and 3 and 4 for the smaller. Both these stones are portions of a larger one, as an examination of different sides shows, the surface of the one side being quite different from that of the other. Fig. 3 represents probably the original surface of the meteorite, Fig. 4 is that of a fractured surface. The black crust on A is perceptibly thicker than that on B.

The external and internal appearance of the two specimens are so similar that one has no hesitation in ascribing it to the same origin.

The larger of the two specimens had been chipped so that a portion of the crust had been removed, and it appeared to consist of a greyish ground mass with brown patches disseminated throughout. Many shining specks of nickel iron and troilite could be seen by the microscope, and the stone was markedly magnetic and showed slight polarity. Attempts were made to obtain sections, but the stone was too hard and at the same time so loosely held together that this was not possible. The exposed surface was then ground flat and polished, and the structure was then very clearly seen (Fig. 5).

Here the masses of nickel iron stand out sharply from the ground mass, their shapes being well represented by those in the centre of the Fig. These masses could be dug out with some difficulty and then appeared to be tough malleable particles, having all the physical properties of an alloy of iron and nickel. The stone was exceedingly hard except where the metallic particles were found, and this made it difficult to polish satisfactorily. "Chondri" could not be definitely detected.

FIG. 1. Magnification, $\frac{5}{9}$. Actual height, 11 cm.

The specific gravity was found in the usual way and was ascertained to be—

Larger fragment	3·536
Smaller fragment	3·551

Both specimens were porous, as was seen during the specific gravity determination. The first specimen weighed in air 1382·2, and in water 989·5, but the latter weight gradually increased to 991·4 after one hour's immersion, so that water to the extent of 1·9 grammes had been absorbed.

The specific gravity given above was calculated from the loss in weight after one hour's immersion.

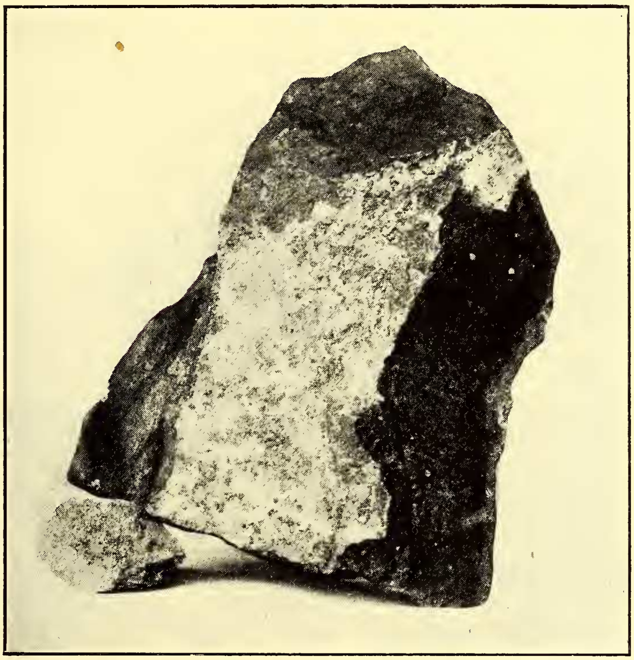

Fig. 2. Magnification, $\frac{5}{9}$. Actual height, 11 cm.

Fig. 3. $\times \frac{1}{2}$.

The second specimen weighed 663 in air, 476·3 in water shortly after the immersion, but after thirty minutes the weight was 475·6. The meteorite was easily crushed, but could not be reduced to a fine powder on account of the metallic particles. These particles were readily separated from the other matter by means of a magnet, and formed more than half of the whole mass. The metallic portion is partially soluble in

Fig. 4. × ½.

dilute sulphuric acid, and completely soluble in aqua regia. Hydrochloric acid attacked the powder with evolution of sulphuretted hydrogen owing

Fig. 5. Magnification, 10 diameters.

to decomposition of the troilite. After digestion for two days with hydrochloric acid and boiling off the sulphuretted hydrogen, the residue was dissolved in aqua regia. Sulphuric acid was now found in the solution, so that the presence of iron pyrites or some other sulphide may be inferred. Qualitative analysis showed the presence of iron, nickel, aluminium, calcium, silicon, and sulphur, and traces of manganese, but no carbonic acid. An exhaustive analysis has not yet been made.

The iron, nickel, and insoluble matter were determined quantitatively. The meteorite was crushed as far as possible in a steel mortar, the tough metallic particle separated by a magnet, and the residue ground further in an agate mortar. The two portions were mixed and weighed. The material was heated upon a water bath with aqua regia until no further action occurred, evaporated three times to dryness with hydrochloric acid, the insoluble matter filtered off, dried, ignited, and weighed. The soluble portion was evaporated with sulphuric acid, to convert into sulphates and made up to a definite volume. In one portion the iron was found by precipitation with ammonia and conversion into ferric oxide, and in another portion the iron was reduced to the ferrous state and titrated with standard permanganate. The nickel was estimated in a portion from which the iron had been removed, by the process given in Crooke's Select Methods.

The chief constituents present are :—

Insoluble matter	54·68
Iron	30·38
Nickel	13·21

As a section could not be obtained, it is difficult to specify exactly the minerals present, save the iron-nickel alloy, troilite, pyrites, and perhaps asmanite, but the siliceous matter was only slightly soluble in sodium carbonate. The general structure seems to be one of aggregation of small more or less rounded particles round a skeleton of the iron-nickel alloy. The non-metallic grains were never complete crystals. On examination in polarised light a few grains of what appeared to be a much-twinned felspar were seen, and brownish grains which showed brilliant colours.

The Winburg Meteorite.

This is a very remarkable specimen of an iron meteorite. As far as can be gathered, it was seen to fall by some natives working on the farm of Zeekoegat in 1881, and reported by them to Mr. Schnehage, the owner of the farm. It was removed to the farmyard and remained there for some years, and was finally deposited in the Bloemfontein National Museum.

As regards its external appearance, it is nearly black and plentifully covered with "thumb" markings, but different surfaces are quite distinct, as the photographs show.

Figs. 6 and 7 are taken from opposite sides. The surface is covered over with well-impressed marks which, in places, show some signs of exfoliation due to surface oxidation, and similar appearances are met with on the top and bottom. Fig. 7 indicates very clearly that the meteorite must have been a portion of a larger mass, and the sharp line at the top,

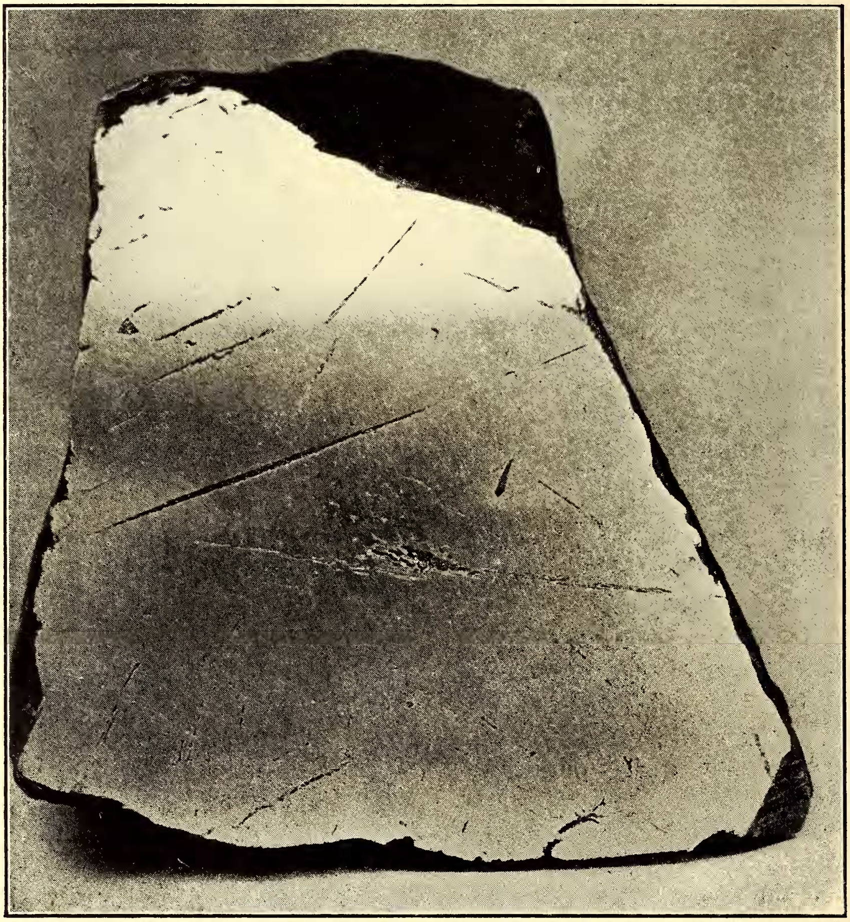

Fig. 8. Actual size. 23 cm. across longest diameter.

and the irregular line running across the surface look very much as though the mass had been torn violently from another piece. The extreme length is 38 cm., and thickness 23 cm., and the weight about 50 kilogrammes. The whole mass is very soft externally, and can be easily indented with a blow of a hammer, and can even be cut with a knife, but there are portions of great hardness.

A section was made across the meteorite, and the exposed surfaces polished. When this was done a number of veins of a much more lustrous metal were seen embedded in the mass of iron, and standing out clearly on account of their brightness. One surface was not further treated, and the other " etched" with dilute nitric acid.

These veins are not uniform, but can be seen with a moderate magnifying power to consist of a metallic network enclosing black particles. Fig. 8 shows the surface polished, but not etched. Fig. 9

Fig. 9. 21 cm. across longest diameter.

shows the surface after etching, and about $\frac{2}{3}$ of the actual size. The area of the polished surface is about 230 sq. cm. In this Fig. the Widmanstatten lines are seen developed, and also the network of the veins. Fig. 9 in Plate VI. shows the lines after etching with stronger acid.

Fig. 10 shows a portion of the surface under a magnificature of 5 diameters. The remarkable triangular arrangement of the interlocking crystals is well shown here; the details of this will be referred to later. The black matter running through the network of the veins is also clearly seen. Small portions of the surface were submitted to higher magnification, and Figs. 11, 12 and 13 are the results. In Fig. 11 is shown a complete crystal, which had a very bright border line, the edges glistening like silver beads under reflected light. The magnification in this case is about 20. Fig. 12 shows another portion; the different reflecting powers of the various constituents enable the individual crystals to stand out clearly from each other.

Figs. 13 and 14 show portions of one of the veins magnified 20 diameters; the carbonaceous matter filling the network is here well defined. At low magnification the etched figures are not so well defined as is usually the case with meteoric irons. The reason for this will be clear

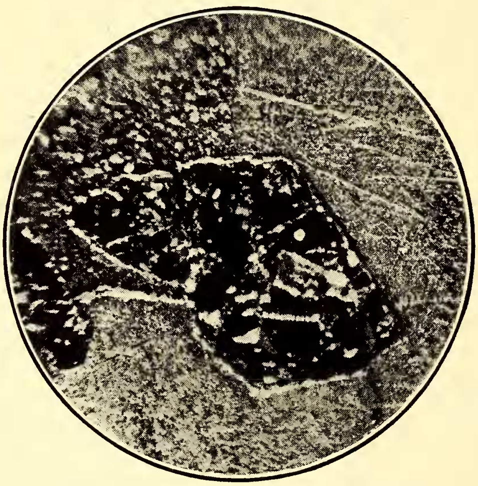

Fig. 11. Magnification, 20 diameters.

when the chemical composition has been explained. The striking feature of the structure seemed to be the presence of the veins composed of a material differing considerably in composition from that of the general mass.

The meteorite is very readily attacked by acids, as might be expected from its purely metallic nature. It dissolves completely in aqua regia, with the exception of a small quantity of earthy matter, which I believe is located only in the veins. Dilute sulphuric also attacked it, but in this case there is an insoluble residue composed of carbon, and also crystals of an alloy of iron and nickel. Practically nothing but iron goes into solution in dilute sulphuric acid, the iron-nickel alloy being insoluble, but dissolving readily in aqua regia.

A small piece of the meteorite with a vein running through it was cut off and digested in dilute sulphuric acid (1/20) for two days. The specimen was arranged upon a perforated disc in a funnel, so that the ferrous sulphate formed by solution of the iron could be drained away without disturbing the residue. When this was done a beautiful skeleton crystalline mass of the alloy remained behind. The interstices were filled with carbon in an amorphous and powdery form. The structure was so fragile that the slightest jar given to the funnel caused it to fall to pieces. A photograph of the debris is shown in Fig. 14, Plate VII. It looks like the remains of an octahedral crystal. One has hopes, with more careful treatment, to obtain one of these skeleton crystals.

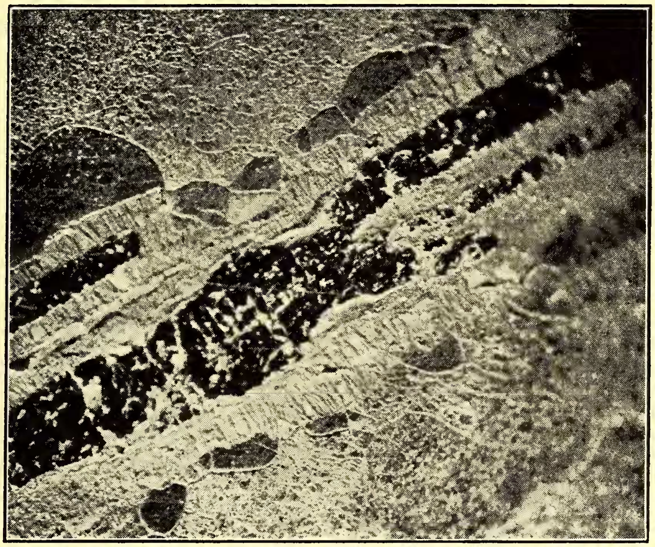

FIG. 13. Magnification, 20 diameters.

The residue usually left behind by solution in dilute sulphuric acid consists of carbon containing siliceous matter and triangular flakes of iron nickel, evidently portions of larger crystalline masses, as Figs. 15, 16, and 17 will show. Some of the flakes attain a length of more than a centimeter, and have bright glistening surfaces. Fig. 15 is a shadow photograph. There is evidently a tendency to cleave into small triangular pieces. Occasionally " cross hatchings " are seen, as in Fig. 10*a*, but as a rule they are not present. The whole mass is distinctly magnetic, having a number of poles which we easily found with a small compass, and magnetic susceptibility was retained by the crystals up to a red heat. The meteorite is thus composed of a mixture of pure iron and iron-nickel alloy, the latter being easily separated. The black residue left with the alloy consisted of carbon—perhaps some hydrocarbon. It ignited readily, and in some cases burnt out with a luminous flame. It dissolved with the alloy on heating in aqua regia.

After solution of the crystalline mass and the carbon in aqua regia, a small residue was left, consisting of microscopic grains of brown or white material. The grains showed brilliant polarisation colours, and appeared to consist of silica. Very careful search was made to ascertain

Fig. 14. Magnification, 20 diameters.

whether any diamonds were present, but no positive evidence was obtained. There were, however, a few transparent particles, more or less hexagonal in form, in which a microlith of a pink mineral was found. The particle had no influence on polarised light, but the pink microlith had, having an extinction angle of about 15°.

Chemical Composition.

Analyses were made (*a*) upon the meteorite as a whole, (*b*) upon the portion soluble in dilute sulphuric acid, and (*c*) upon the crystals of the alloy.

(*a*) Some cuttings weighing about 1 gramme were dissolved in aqua regia, evaporated to dryness with sulphuric acid, the ferric salt reduced, and the amount of iron found by titration with permanganate. The amount found varied between 94 and 95 per cent.

(*b*) The cuttings were digested with dilute sulphuric acid, and the amount of iron found by permanganate. The average was 92·32 per cent.

(*c*) A weighed portion of the crystals of the iron-nickel alloy were dissolved in aqua regia, the iron determined in one portion of the solution and the nickel in another. The mean of several analyses gave an extra 2·35 of iron, and 2·00 per cent. for the nickel, calculated upon the meteorite as a whole.

The composition of the meteorite as regards its main constituents may thus be summarised:—

Iron soluble in dilute sulphuric acid	92·32
Iron in crystals	2·35
Nickel in crystals	2·00
Carbon and earthy matter	0·3

The meteorite, then, appears to be a mass composed of crystals of iron-nickel alloy embedded in a matrix of iron, with only a very small amount of nickel in the general mass.

The total percentage of nickel is small, and most of it is concentrated in the vein of the alloy running through the mass.*

My thanks are due to the Committee of the Bloemfontein Natural Museum for permission to examine the structure of the meteorite.

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* A complete chemical examination has not yet been made.